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Determination of optimum ripeness for edibility of postharvest melons using nondestructive vibration

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A B S T R A C T

We investigated time-course changes in the elasticity index (EI) of two melon (*Cucumis melo* L.) cultivars ("Andes" and "Quincy") during their postharvest period. The EI was determined using the formula $EI = f_2^2 \cdot m^{2/3}$, where f_2 and m were the second resonance frequency and the mass of the sample, respectively. A nondestructive vibrational method with laser Doppler vibrometer (LDV) was used for measuring the second resonance frequency (f_2) of the melon samples. The changes in the EI of both cultivars showed quasi-exponential and biphasic decays. Along with sensory tests, we determined the optimum ripeness for edibility of the melons in terms of their EI to be $4.2–6.3 \times 10^4\ kg^{2/3}\ Hz^2$ ("Andes") and $4.5–5.6 \times 10^4\ kg^{2/3}\ Hz^2$ ("Quincy"). Therefore, predetermined EI of two melon cultivars enables consumers to predict the time range of optimum ripeness.

1. Introduction

Consumers are interested in the period of optimum ripeness for edibility of melons as they continue to ripen even after harvest. However, melons exhibit various degrees of ripeness in a market; thus, making it difficult for consumers to assess the optimum ripeness for eating. To help solve this problem, we investigated the period of optimum edibility of melons using a nondestructive method. This method is based on the fact that melons loose firmness in postharvest ripening. The predetermined period of optimum ripeness helps consumers to choose the timing for optimum edibility. Moreover, the data provides distributors with a base for monitoring the ripening process and helps determine when to ship commodities.

Many researchers have developed various methods of measuring the firmness of a fruit. Mechanical methods include the measurement of: elastic deformation, velocity of sound transmission in fruit, and acoustic resonance. Takao and Ohmori (1994) developed a firmness tester that was based on measuring elastic deformation. They confirmed the use of the device for measuring the firmness of kiwifruits and melons during postharvest ripening. A similar method was used by Davie, Banks, Jeffery, and Studman (1996) for measuring deformation under constant load, which caused negligible damage to fruit. A more sophisticated method is a laser air-puff detector developed by Hung, Prussia, and Ezeike (1999) for nondestructive measurement of fruit firmness. In this method, the firmness of peaches was determined by the amount of surface deformation made by an air-puff. The method was used to investigate the firmness of kiwifruits by McGlone, Ko, and Jordan (1999). Sugiyama, Otobe, Hayashi, and Usui (1994) studied the velocity of sound transmission in fruit and found that the velocity slowed down as the fruit ripened. Later, Sugiyama, Katsurai, Hong, Koyama, and Mikuriya (1998) developed a more practical device for evaluating the firmness of fruit based on the same principle. Muramatsu, Sakurai, Yamamoto, et al. (1997) also used the velocity of sound transmission to measure the firmness in kiwifruit. Yamamoto and Haginuma (1982), and Yamamoto, Iwamoto, and Haginuma (1981) used an acoustic impulse response resonance method to evaluate the firmness of fruit. Muramatsu, Sakurai, Wada, et al. (1997) showed that a method involving the use of laser Doppler vibrometer (LDV) was advantageous for determining the firmness of fruit. This method has been applied to monitoring the ripeness of kiwifruits (Terasaki, Sakurai, Yamamoto, Wada, & Nevins, 2001; Terasaki, Wada, et al., 2001) and pears (Terasaki et al., 2006). More practical devices have been developed for evaluating the ripeness of melons. For instance, the elasticity index of melon fruit being grown in a greenhouse was measured using a portable device based on an acoustical vibration technique (Kuroki, Tohro, & Sakurai, 2006).

Therefore, in the present study, we measured time-course changes in the elasticity index (EI) and sensory test index of melons at the postharvest stage. Using the correlation between the EI and the sensory test index, we determined the period of

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optimum ripeness for edibility of melons, which serves as an excellent indicator for optimum quality for eating.

2. Materials and methods

We used two cultivars of melon (*Cucumis melo* L.), "Andes" and "Quincy", for our investigations. The samples were grown and harvested in Kumamoto Prefecture, Japan. Twenty samples of each cultivar were used and stored at room temperature (ca. 20 °C and ca. 50% RH) throughout the measurements.

The sensory test was performed by two experts (both male). Each panelist graded the samples for hardness, sweetness, fibrousness, thickness, fragrance, appearance, and overall acceptability. The samples were rated on a scale of 1–5 (1: overripe, 3: ripe, and 5: immature) every day or every other day for a total period of 10 days.

The EI of each sample was determined nondestructively every day or every other day immediately before the sensory test, using a previously reported vibrational method (Muramatsu, Sakurai, Wada, et al., 1997). The experimental setup is shown in Fig. 1a. A sample with a reflective film was set on an electrodynamic shaker

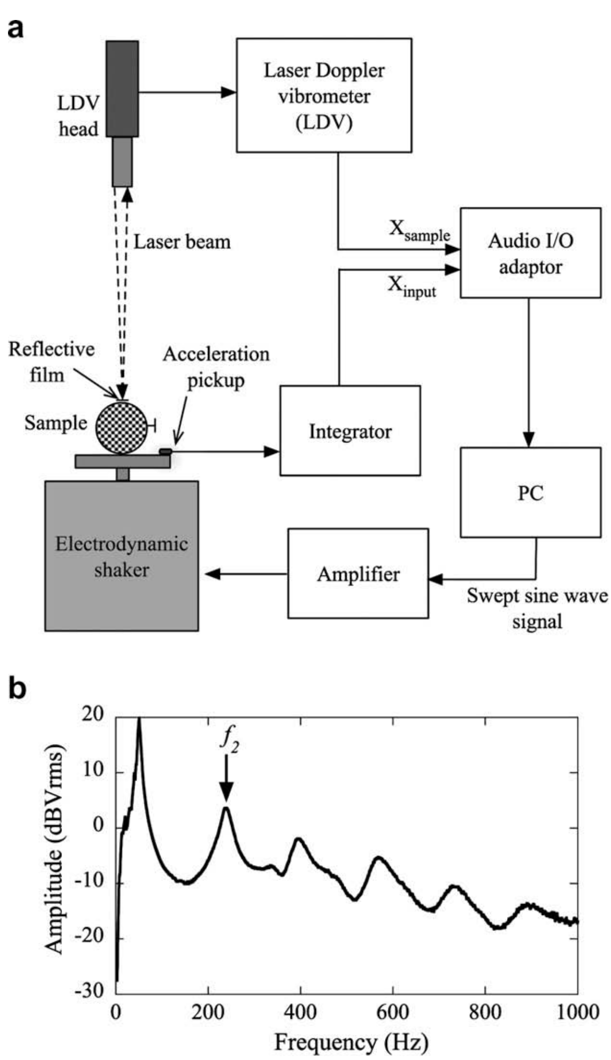

Fig. 1. (a) Experimental setup for the nondestructive measurement of the EI of the melon samples. The sample was mechanically excited by a shaker that was driven by swept sine wave signals. The response at the opposite side of excitation was sensed by a laser Doppler vibrometer (LDV). (b) A typical response spectrum of an "Andes" melon sample; f_2: the second resonance peak that was used for determining the EI.

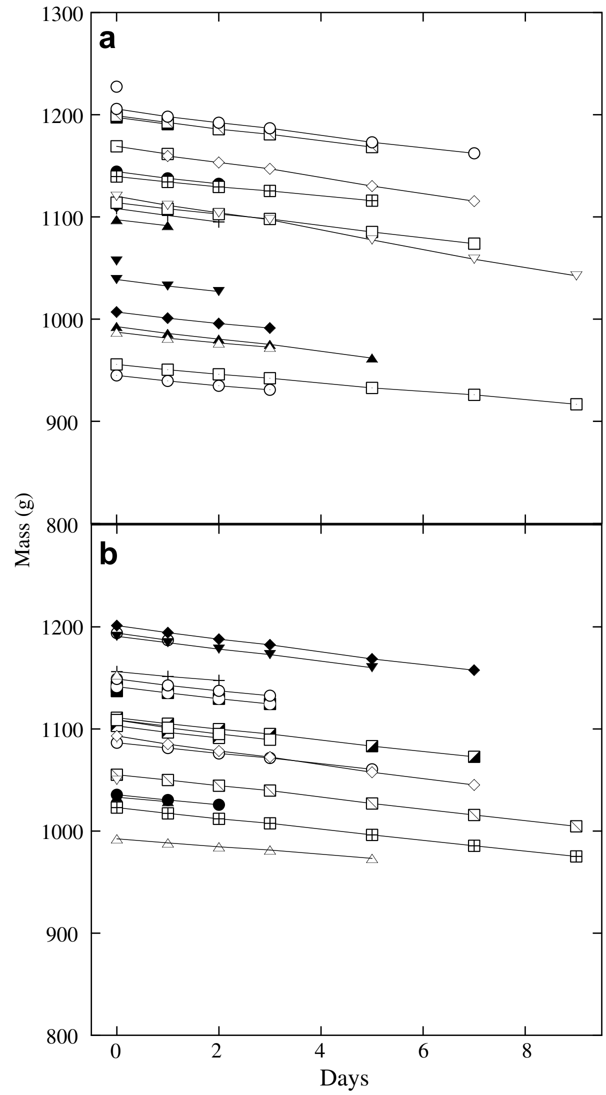

Fig. 2. Time-course changes in the mass of the melon samples: (a) "Andes" and (b) "Quincy".

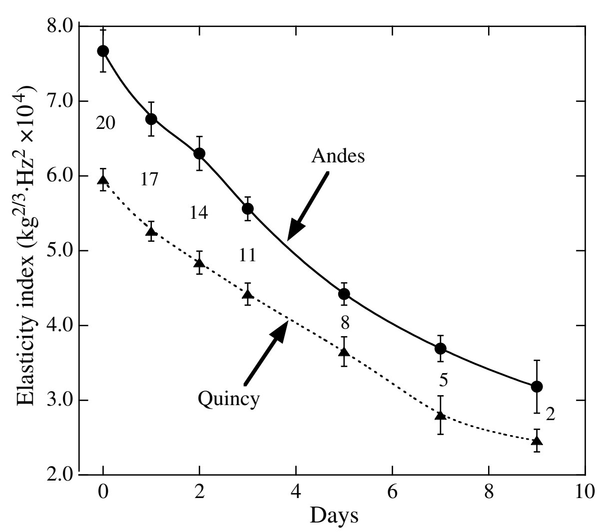

Fig. 3. The time-course changes in the averaged EI of "Andes" and "Quincy" melons determined by the method described in Fig. 1. The bars represent the SE. The numbers represent the number of samples used for each measurement.